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AUTHOR	Shaw, David C.; Johnson, Dorothy M.
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ABSTRACT

The complete comprehension of this paper requires a firm grasp of both mathematical demography and FORTRAN programming. The paper aims at the establishment of a language with which complex demographic manipulations can be briefly expressed in a form intelligible both to demographic analysts and to computers. The Demographic Computer Library (DCL) has been structured around three interrelated operations: Life table construction, stable population generation, and population projection. Life table construction is fundamental to the other two operations. The subroutines of the DCL have been written as parts of a system. The output of one subroutine is available for immediate use by any of a number of other subroutines. Other examples of DCL flexibility are given in part IV. The contribution of the DCL to demographic analysis consists of reducing the drudgery and delays required by the multitude of mathematical computations. The DCL, cannot, however, claim to endow the nondemographer with the ability to produce high quality demographic analysis. (Author/NH)

technical paper

DEMOGRAPHIC COMPUTER LIBRARY

25

by David C. Shaw and Dorothy M. Johnson

Issued June 1971

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The centerpiece of the Demographic Computer Library (DCL) is a computer program which generates a specified Regional Model Life Table (subroutine MLTX). Since all of the other parts of the DCL can be looked upon as appendages of MLTX, the authors are indebted especially to **Dr. Ansley Coale** and **Dr. Paul Demeny**, who developed the model life table methodology.

The authors wish to express their thanks to **Dr. Richard Hornseth** and **Chris Jorgensen** for programing MLTX, to **Reginald Masano** for valuable programing support, and to **Mildred Goff**, **Naomi Donovan**, and **Dolores Adams** for their typing and proofreading assistance.

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I. Introduction

This paper requires a firm grasp of both mathematical demography and FORTRAN programing for complete comprehension. Subsequent papers can aim at developing one or another of the seminal capabilities presented here or at minimizing the programing or demographic skill requirements for effective use. This paper aims at the establishment of a language with which complex demographic manipulations can be briefly expressed in a form intelligible both to demographic analysts and to computers.

The Demographic Computer Library (DCL) has been structured around three interrelated operations: Life table construction, stable population generation, and population projection. Life table construction is fundamental to the other two operations. A stable population cannot be generated without a life table nor can a population distribution be projected.

The subroutines of the DCL have been written as parts of a system. The output of one subroutine is available for immediate use by any of a number of other subroutines. Once a life table has been constructed, for example, several avenues are open to the programer with a single CALL statement. He can print the life table (CALL PLT (NROW)), generate a stable population (CALL SPP (R)), or load the survival ratios of the life table into the projection table (CALL LSR (NSEX)). Other examples of DCL flexibility will be given in part IV.

At present, the inclusion of computer programs with the documentation of a scientific publication is generally not tenable due to the length of the programs and the difficulty of reading unfamiliar programs. If a library came into general use, both of these obstacles would be overcome. A short main program could easily communicate a complex sequence of computations to those familiar with the library. The DCL is an early attempt at a small but basic portion of such a library and the DCL should be evaluated from this point of view.

The case studies in part IV illustrate the amount of computational work achieved in relation to the number of program instructions. Note that FORTRAN instructions other than the CALL statements to DCL subroutines can be combined as desired with these CALL statements. The system has "canned" program features but remains open for modification by the programer. Although the fundamental operations of the DCL can be programed with almost no knowledge of FORTRAN, the firmer the programer's grasp of FORTRAN the more varied will be the results obtainable with the DCL.

The nonprogramer who wishes to understand the DCL as a system of computer programs to use the system more effectively should obtain information about the following programing concepts:

1. Program
2. Main program
3. Subprogram
4. Subroutine
5. SUBROUTINE statement
6. CALL statement
7. RETURN statement
8. Calling program and called program
9. The communication of information between calling program and called program by means of either:

A. The arguments of the CALL and SUBROUTINE statements
B. The COMMON statement

If these concepts are understood, intelligent application of the DCL should be possible even for a deomographer who lacks understanding of other fundamental programing concepts and is, therefore, unable to program. The program listings (part V) will remain intelligible only to the programer.

The nondemographer who wishes to understand the DCL as a demographic computer system to use the system more effectively should obtain information about the following demographic concepts and associated methodologies: Life table, stable population, quasi-stable population, and component population projection. The contribution of the DCL to demographic analysis consists of reducing the drudgery and delays required by the multitude of mathematical computations. The DCL cannot, however, claim to endow the nondemographer with the ability to produce high quality demographic analysis.

The DCL is presently operative on the following computers: Univac 1107, IBM 360/40, and GE 635 (time sharing). Copies of the DCL source programs (IBM 360 version) can be obtained on magnetic tape. For further information write to:

Director
International Demographic Statistics Center
U.S. Bureau of the Census
Department of Commerce
Washington, D.C. 20233
Attn: DCL

II. Subroutine Linkage

There are two ways to communicate between a calling program (a main program or a subroutine) and a called program (always a subroutine). The first way is through a COMMON statement. Most of the subroutines of the DCL are linked together primarily by means of a standard COMMON statement which has the form COMMON A(21,9), B(21,8), C(51), where A represents the life table array, B represents the projection table array, and C represents the array containing the parameters of a stable population. These names need correspond only with the name used for the array in question in the program in which the COMMON statement appears. The order of the arrays, however, must be that indicated in the standard COMMON above. For example, one subroutine may contain one of the following standard COMMON statements and another subroutine the other statement without mishap

COMMON A(21,9), B(21,8), C(51)
COMMON C(21,9), Z(21,8), A(51)

as long as the first array name in each COMMON statement corresponds to the array name for the life table in the program in which the COMMON statement appears. One of the following COMMON statements appearing in one subroutine and the second COMMON statement in another subroutine would cause a communication breakdown:

COMMON A(21,9), B(21,8), C(51)
COMMON B(21,8), C(51), A(21,9)

The second way to communicate between a calling program and a called program is through the arguments of a CALL statement. Although a called program can be linked to a calling program both by a COMMON statement and by the arguments of a CALL statement, communication of the same information by both methods is not permitted. It is important to note that in the DCL, the standard life table, stable population, and projection arrays are always communicated by means of the COMMON statement and these arrays are, therefore, never communicated through the arguments of a CALL statement.

Examples of the information usually communicated through the arguments of a CALL statement in the DCL are the life expectancy at birth, the sex code, and the region code for the model life tables (CALL MLT (EX, NSEX, NREG)), or the rate of increase to be used in generating a stable population (CALL SPP (R)).

When writing main programs that use the DCL, the programer should include the standard COMMON statement and be sure that the arguments (if any) of the CALL statements of the main program correspond to those of the DCL SUBROUTINE statements. A description of each subroutine in the DCL including the required form of the CALL statement in the calling program is presented in part III. A firm comprehension of these descriptions is necessary for the effective use of the DCL. Part IV will illustrate some frequent DCL applications.

III. Subroutine Descriptions

This part is divided into three sections which correspond to the three principal DCL operations. Each of these sections begins with a description and discussion of the principal array for the corresponding operation.

Note that throughout the DCL, birth rates, fertility rates, death rates, rates of natural increase, and sex ratios are expressed not per 100 or 1,000 population but on a unit basis (per person). For example, a 1 percent rate of natural increase is expressed .010.

A. Life Table Related Subroutines

In order to achieve a mastery in the use of the DCL, the user should be aware of the contents of the arrays being manipulated, otherwise much of the flexibility of the system will be lost. Although many of the operations of the DCL take place without requiring the user to discriminate among the elements of the principal arrays, several additional important capabilities are at the command of the user who takes some care in noting these details.

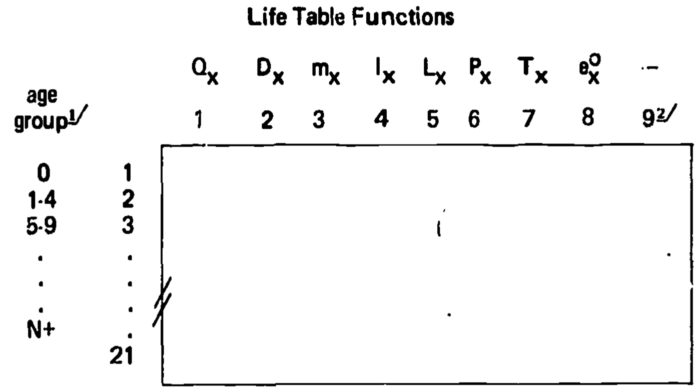
The first array of the standard COMMON statement (with dimensions 21 by 9) represents the DCL life table array. Whether the life table is a model or an empirical one, not only the dimensions but also the column definitions (excluding column 9) of the table are identical. The column definitions of all life tables constructed by the DCL will always be as shown in diagram 1. All age groups except the first two and the last (N+) represent consecutive 5-year intervals. The final age group of the table is determined by the number of input Q_x values. The final age group represents an open ended interval with a maximum lower boundary of 95. That is, the open interval 95+ would fall in row 21, the last possible row of the table as dimensioned. The model life tables use 18 rows of the table with N equal to 80.

It is assumed that the user understands that certain of the life table columns are defined in relation to the lower boundary of the interval (l_x, T_x, e_x^o) rather than in terms of the interval itself. This understood, the only exception to the row definitions as presented is column 6, the survival ratios. These represent 5-year groups throughout the column. The first ratio represents survival from birth, the second survival from the 0-4 interval, etc. Beginning with row 3, the denominators of the ratios correspond to the row definitions of all the other columns. The last row of the life table has a survival ratio of zero.

Much further use can be made of life table columns L_x (for generating stable populations) and P_x (for projecting population distributions).

1. **Subroutine MLTX.** An understanding of this complex subroutine is not essential for all users. It is recommended that the beginner proceed to subroutine MLT after scanning this description of MLTX.

Diagram 1. Formal Content Definition for the DCL Life Table Array.



[1] See text for explanation of N+.
[2] See part III, A1 for explanation of positions 1,9 and 2,9. See part III, A2 for an explanation of position 3, 9. See part III, C1 for an explanation of positions 4, 9 and 5,9. Note that in the subroutines of the DCL, subscripts representing rows always precede subscripts representing columns in accordance with statistical convention.

MLTX computes a regional model life table[1] for the level, sex, and region specified in the CALL statement. The required form of the CALL statement is:

CALL MLTX (ET, NSEX, NREG)

CALL statement arguments (all inputs):

ET. The life expectancy at birth of the life table constructed will rise and fall together with this independent variable. No fixed relationship has been found, however, between this control variable and the life expectancy at birth of the resulting life table. A life table of desired life expectancy at birth can be obtained by successive iterations. (See description of Subroutine MLT below.)

NSEX, NREG. There is a series of model life tables for each sex and each of four regions as described in the text cited. Here the codes for sex (NSEX) and region (NREG) as recognized throughout the DCL are as follows: NSEX: 1 = female, 2 = male. NREG: 1 = West, 2 = North, 3 = East, 4 = South.

The output of MLTX (a model life table) is placed in the standard life table array of the standard COMMON statement (last age group is 80+, in row 18). In addition to the life table, MLTX places the value of the associated control variable, ET, in position 1, 9 of the standard life table array, and the control variable that will produce the life table of the opposite sex of the same region, according to the relationship of the model life tables, in position 2, 9 of the standard life table array.[2]

The methodology for obtaining the Q_x values of the model life tables is complex. No explanation is attempted here. The reader is referred to chapter 2 of the Coale-Demeny volume, and also to the MLTX program listing in part V of this paper.

From a given set of q_x values, MLTX computes d_x and l_x values as follows:

$$d_x = q_x \, l_x, \; l_0 = 100{,}000, \; x = 0,1,5,10,\ldots,80$$

$$l_{x+n} = l_x - {}_nd_x, \; x = 0,1,5,10,\ldots,75$$

[1] Ansley J. Coale and Paul Demeny Regional Model Life Tables and Stable Populations (Princeton University Press, Princeton, New Jersey, 1966).
[2] See Coale-Demeny, op. cit., p. 23. See also below part IV, case 2.

The formulas for the remaining life table columns taken directly from the Coale-Demeny volume are as follows:

$_nL_x$ and e_x^o were estimated on the use of the following formulas:

$$_1L_0 = k_0 l_0 + (1 - k_0) l_1$$

$$_4L_1 = k_1 l_1 + (4 - k_1) l_5$$

$$_5L_x = 2.5(l_x + l_{x+5}),\ x = 5,10,\ldots,75$$

$$e_{80}^o = 3.725 + (0.0000625)(l_{80})$$

$$T_{80} = e_{80}^o\, l_{80}$$

$$L_{80} = T_{80}$$

$$T_x = \sum_{x}^{75} L_x + T_{80}$$

$$e_x^o = \frac{T_x}{l_x}$$

The values of k_0 were as follows, when $_1q_0 \geq 0.100$:

	For Females	For Males
West, North, South "Regions"	0.35	0.33
East "Region"	0.31	0.29

The values of k_0, $_1q_0 < 0.100$, were given by the following expressions:

	For females
West, North, South	$k_0 = 0.050 + 3.00\ {}_1q_0$
East	$k_0 = 0.010 + 3.00\ {}_1q_0$

	For males
West, North, South	$k_0 = 0.0425 + 2.875\ {}_1q_0$
East	$k_0 = 0.0025 + 2.875\ {}_1q_0$

The values of k_1 were as follows, when $_1q_0 \geq 0.100$:

	West	North	East	South
For females	1.361	1.570	1.324	1.239
For males	1.352	1.558	1.313	1.240

The values of k_1, $_1q_0 < 0.100$, were given by the following expressions:

	For females	For males
West	$1.524\text{-}1.625\,{}_1q_0$	$1.653\text{-}3.013\,{}_1q_0$
North	$1.733\text{-}1.627\,{}_1q_0$	$1.859\text{-}3.013\,{}_1q_0$
East	$1.402\text{-}1.627\,{}_1q_0$	$1.541\text{-}3.013\,{}_1q_0$
South	$1.487\text{-}1.627\,{}_1q_0$	$1.614\text{-}3.013\,{}_1q_0$

Age-specific mortality rates ($_nm_x$) were calculated from the formula $_nm_x = {}_nd_x / {}_nL_x$.

Five-year survival rates for projecting 5-year age groups ($_5P_x$) were calculated by the formula $_5P_x = {}_5L_{x+5} / {}_5L_x$, $x = 0, 5, \ldots, 70$.

The first survival rate is the proportion surviving to the end of a 5-year time interval of persons born during the interval, estimated as $_5L_0 / 5l_0$. The last survival rate is of persons over 75 at the beginning of an interval (and over 80 at the end), estimated as T_{80}/T_{75}.[3]

[3] Ibid., pp. 20, 23.

The control variable for the opposite sex associated with the CALL statement argument ET is obtained by solving the following equation for ETM or ETF as required:

ETM-EXM = (SM/SF) (ETF-EXF)

where ETM and ETF are the control variables for males and females respectively, one of which is given and the other is unknown. The value of the other factors for each region are presented below.

	West	North	East	South
EXM	55.749	53.922	54.064	53.054
EXF	58.540	56.622	56.664	55.590
SM	4.604	5.911	4.682	4.755
SF	5.046	6.112	5.383	5.601

For an explanation of the formula, consult page 23 of the Coale-Demeny volume. These factors which do not appear in the text were obtained directly from the authors.

Although the user will seldom made a call to MLTX directly (it is generally called indirectly through MLT), it is clearly the foundation of the entire system.

2. Subroutine MLT. MLT places in the standard life table array a model life table of the life expectancy at birth, the sex, and the model life table region indicated in the CALL statement. The required form of the CALL statement is:

CALL MLT (EX, NSEX, NREG)

where EX indicates life expectancy at birth, NSEX is the sex code (1 = females, 2 = males), and NREG is the region code (1 = West, 2 = North, 3 = East, 4 = South).

MLT calls MLTX repeatedly until a model life table is obtained whose life expectancy at birth differs by not more than .001 of one year from the life expectancy indicated by the CALL statement. If greater precision is desired, subroutine MLT can be easily modified to achieve this. The number of iterations required to satisfy the specified level of precision is placed in position 3, 9 of the standard life table array. For the .001 level of precision, the number of iterations is generally between 3 and 5.

3. Subroutine ELT. ELT constructs a life table using a series of Q_x values entered in column 1 of the standard life table array prior to a call to ELT. The CALL statement must be of the form:

CALL ELT (NSEX)

where NSEX is the sex code: 1 = females, 2 = males.

The life table is placed in the standard life table array. Apart from the exceptions noted below, the special problems in life table construction are resolved by ELT in the same manner as stated in the description of subroutine MLTX above. In computing $_1L_0$ and $_4L_1$, the K_0 and K_1 factors of the West region are always used. The following ELT formulas are somewhat different from those of MLTX:

$$L_n = l_n \log_{10} l_n$$

$$T_x = \sum_{a=x}^{n} L_a$$

$$e_n^o = T_n / l_n$$

where n is the lower boundary of the final, open-ended age group. The last Q_x value should be 1.0. If it is not, ELT will change the last nonzero cell in column 1 of the standard life table array to 1.0 before proceeding. The final age group of the life table is implicit in the length of the list of Q_x values entered.

4. Subroutine MXQX. MXQX converts a series of empirical M_x values to Q_x estimates by means of the Reed-Merrell method. The CALL statement must be of the form:

CALL MXQX (EMX, NSEX)

where EMX is an array containing the M_x values (unit basis) and NSEX is the sex code: 1 = females, 2 = males.

EMX must be dimensioned EMX (21) in the calling program regardless of the actual number of M_x values entered. The set of M_x values must represent in succession the standard 5-year life table age groups; i.e., 0-1, 1-4, 5-9, 10-14, etc. The Reed-Merrell method is not used for the first two Q_x estimates. The value entered in the first position of array EMX is assumed to represent total deaths below age one (male or female) divided by total births for the same 12-month period as the M_x values. This value is directly accepted as the Q_0 estimate without change. The estimate for ${}_4Q_1$ is obtained by resolving the formula:

$$4\,{}_4M_1/(1+(4-k_1)\,{}_4M_1)$$

where k_1 is the same as West region k_1 as presented in the description of subroutine MLTX. The Q_x value for the position following the final M_x input is set to 1.0. For the remaining 5-year age groups, Q_x values are computed from the given M_x values by means of the following Reed-Merrell formula:

$${}_5Q_x = 1 - e^{5\,{}_5M_x^3}$$

where e is the base of the natural logarithms.[4] The Q_x estimates (unit basis) are placed in column 1 of the standard life table array in order that a call to ELT can follow immediately if desired. See part IV, case 3.

[4] J. L. Reed and M. Merrell, "A Short Method for Constructing an Abridged Life Table," The American Journal of Hygiene, Vol. 30, No. 2, pp. 33-62, September, 1939. For an introductory presentation see George Barclay, Techniques of Population Analysis (Wiley, New York, 1958) appendix to chapter 4 paragraph 4:16.

5. Subroutine PLT. PLT is a subroutine which prints the contents of the standard life table array. The output is labeled as in table 1 below. The required form of the CALL statement is:

CALL PLT (NROW)

where NROW specifies the number of rows to be printed (a positive integer number not greater than 21).

B. Stable Population Related Subroutines

Once a life table (model or empirical) is present in the standard life table array, an age structure and many other parameters of a stable population can be easily generated simply by specifying a rate of natural increase. A call to the DCL stable population generating subroutine (SPP) results in a large selection of stable population parameters being placed in the standard stable population array. For a detailed list of the contents of the 51 positions of this array, see part III, B 2. The proportions in various age groups of a stable population are computed by means of the formula:

$$C(x) = e^{-rx}\,L_x / \Sigma e^{-ra}\,L_a$$

where C(x) is the proportion of total population in the age group whose midpoint is x; e is the base of the natural logarithms; r is the rate of natural increase; L is the life years column of a life table for that age group whose midpoint is x; and a is simply a variable expression for x.

This formula and the formulas for the computation of other stable population parameters found in the standard stable population array are adequately explained in the demographic literature.[5] A painstaking presentation is not attempted here.

[5] See The Concept of a Stable Population, U.N., ST/SOA/SER.A/39 Sales No.: E.65, .XIII.3.

Table 1. **Sample Output for Subroutine PLT**

AGE[1]	Q(X)	D(X)	M(X)	l(X)	L(X)	P(X)	T(X)	E(X)
0	0.11831	11831.	.12816	100000.	92310.	.85661	4999978.	50.00
1	0.07170	6321.	.01881	88169.	335995.	.94523	4907668.	55.66
5	0.02136	1748.	.00432	81848.	404870.	.98100	4571672.	55.86
10	0.01659	1329.	.00335	80100.	397177.	.98042	4166803.	52.02
15	0.02261	1781.	.00457	78771.	389402.	.97430	3769626.	47.86
20	0.02886	2222.	.00586	76990.	379396.	.96927	3380224.	43.90
25	0.03266	2442.	.00664	74768.	367736.	.96518	3000828.	40.13
30	0.03704	2679.	.00755	72326.	354933.	.96077	2633092.	36.41
35	0.04151	2891.	.00848	69647.	341007.	.95608	2278159.	32.71
40	0.04644	3100.	.00951	66756.	326029.	.94998	1937152.	29.02
45	0.05376	3422.	.01105	63656.	309722.	.93753	1611123.	25.31
50	0.07168	4317.	.01487	60233.	290373.	.91695	1301401.	21.61
55	0.09530	5329.	.02001	55916.	266257.	.88344	1011029.	18.00
60	0.14005	7085.	.03012	50587.	235223.	.83317	744771.	14.72
65	0.19797	8612.	.04394	43502.	195981.	.76028	509648.	11.71
70	0.29177	10[illegible].	.06832	34890.	149001.	.65661	313567.	8.99
75	0.41629	10287.	.10514	24710.	97835.	.40550	164566.	6.66
80	1.00000	14424.	.21615	14424.	66731.		66731.	4.63

[1] This sample is the result of a CALL PLT(18) instruction following a CALL MLT(50.,1,1) instruction.

1. Subroutine SPP. Using the L_x column of the life table present (by means of a previous call to MLTX, MLT, or ELT) in the standard life table array, SPP generates the selected list of stable population parameters (see part III, B2). The results are placed in the standard stable population array. The CALL statement must be of the form:

CALL SPP (R)

where R represents the rate of natural increase (unit basis).

2. Subroutine PSPP. PSPP prints the selected stable population parameters together with labels. The CALL statement must be of the form:

CALL PSPP

A sample of PSPP output is shown in table 2. The numbers to the left of the line indicate the address of the standard stable population array position containing the parameter. These numbers are not part of PSPP output but will be necessary if the programer wishes to manipulate the contents of the array directly (that is, without using the DCL subroutines). See part IV, case 4.

C. Projection Related Subroutines

Projection, the third principal operation of the DCL, is more complex, has more related subroutines, and demands closer attention than the first two principal operations. The subroutines connected with the projection operation can most easily be described in relation to the standard projection table. Each of these subroutines either loads data into the projection table prior to projection or carries out the computations of the projection process (that is, manipulates the data within the projection table) or prints the contents of the projection table. Before describing the individual projection related subroutines, therefore, attention must be directed to the standard projection table and its position definitions which are presented in diagram 2.

Note that the formal inputs required for a projection are found in the first five columns of the projection table. These formal inputs are: population distributions (male and female), survival ratios (male and female), fertility rates, and the sex ratio at birth. There can be no quarantee that the data selected to satisfy the formal input requirements for projection will constitute a set of reconciled parameters. The selection of the proper data to satisfy these formal input requirements requires a great deal of demographic understanding, which this paper does not attempt to provide.

As a general rule each row of the projection table represents information for a 5-year age group except the last which represents an open ended interval. The survival ratios (columns 3 and 4) have the same row positions as they had in the life table (see part III, A). That is, they occupy the row corresponding to the age group of the survival ratio numerator. Thus, the survival ratios of the incoming birth cohort occupy the first row position. The sex ratio at birth (unit basis, males/females) is found in row 1, column 5. Fertility rates (unit basis) are found in rows 4 to 10, column 5.

Columns 6 and 7 contain the projected age distributions. Column 8 contains a selection of statistics summarizing the contents of the projecting table. These statistics as well as the projected age distributions are computed in connection with the projection process.

Before projection can take place, the required inputs listed above must be loaded into the first five columns of the standard population table. Six simple subroutines are available to assist the user in this loading operation. (All of these subroutines begin with the letter "L".)

Table 2. **Sample Output for Subroutine PSPP**

The address of the stable population array position containing the parameter[2]	PSPP Output[1]	
	label[3]	parameter
5	0-1	2.52
6	1-4	8.95
7	5-9	10.31
8	10-14	9.62
9	15-19	8.97
10	20-24	8.32
11	25-29	7.67
12	30-34	7.04
13	35-39	6.43
14	40-44	5.85
15	45-49	5.29
16	50-54	4.71
17	55-59	4.11
18	60-64	3.46
19	65-69	2.74
20	70-74	1.98
21	75-79	1.24
22	80+	0.79
23	TOTAL	100.00
24	1	2.52
25	5	11.47
26	10	21.78
27	15	31.40
28	20	40.37
29	25	48.69
30	30	56.36
31	35	63.40
32	40	69.83
33	45	75.68
34	50	80.97
35	55	85.68
36	60	89.79
37	65	93.25
38	TOTAL	100.00
39	BIRTH RATE	.02745
40	DEATH RATE	.01745
41	GRR(27)	1.772
42	GRR(29)	1.831
43	GRR(31)	1.894
44	GRR(33)	1.962
45	AVERAGE AGE	29.41
46	PROP. 15-44	44.28
47	BR./P.15-44	0.062
48	POP-4/15-44	0.259
49	POP.5-14/5+	0.225
50	DEP RATIO	0.713
51	P. SZ.B(0)=1	36.432

[1] This sample is the result of a CALL PSPP instruction following a CALL SPP(.010) instruction following a CALL MLT(50.,1.1).

[2] The first four positions of the array are not defined.

[3] The selection of stable population parameters as well as the labels are the same as those in the Coale-Demeny volume (chapter 2B). The labels corresponding to addresses 5 to 22 refer to the percent of total population in mutually exclusive age groups. The labels corresponding to addresses 24 to 37 refer to the cumulative percent of total population from age zero up to but not including the age indicated in the lable. Other labels which require some explanation are defined below.

GRB(X):	Gross reproduction rate when the mean age of the fertility schedule is X years.
PROP. 15-44:	Proportion of the population 15 to 44 years of age.
BR./P.15-44:	Births per person 15 to 44 years of age.
POP-4/15-14:	Persons less than 5 per person 15 to 44.
DEP RATIO:	Dependency ratio; the sum of persons less than 15 years and persons more than 59 years divided by persons 15 to 59.
P.SZ.B(0)=1:	The reciprocal of the birth rate.

Diagram 2. Formal Content Definition for the DCL Projection Array

Column

Row	1. Male Population	2. Female Population	3. Male Survival Ratios	4. Female Survival Ratios	5.	6. Projected Male Population	7. Projected Female Population	8.
1					SRB			———
2					———			Total Births
3					———			Total Deaths
4					Fertility Rates			Total Col. 1
5								Total Col. 2
6								Total Col. 6
7								Total Col. 7
8								Midyear Total
9								CBR
10								CDR
11					———			RNI
12					———			———
13					———			———
14					———			———
15					———			———
16					———			———
17					———			———
18					———			———
19					———			———
20					———			———
21								

Definition of Symbols:

SRB: sex ratio at birth, unit basis.
Total Births (Deaths): 5-year period.
Midyear Total: that is, middle of 5-year period. (one-half of the sum of columns 1,2,6,7)
CBR: crude birth rate, midyear, unit basis. One-fifth of total births divided by total midyear population.
CDR: crude death rate, midyear, unit basis. One-fifth of total deaths divided by total midyear population.
RNI: rate of natural increase. (CBR - CDR)
———: blank

1. Subroutine LSP. LSP loads a stable population percent age distribution (5-year groups to 80+) into the first or second column of the projection table depending on the definition of the sex code. The stable population must be available in the standard stable population array (through a previous call to SPP). The CALL statement must be of the form:

CALL LSP (NSEX)

where NSEX represents the sex code (1 = female, 2 = male).

Before returning to the calling program, LSP places the birth rates into column 9 of the standard life table array. The birth rate is placed in row 4 if the sex is male; in row 5 if the sex is female. This feature makes possible the calculation of a weighted birth rate (see subroutine LMFPX) once the male and female population totals have been assigned (see subroutine PART). Case study number 6 (part IV) illustrates how this feature can be exploited.

2. Subroutine LSR. LSR loads the survival ratios present in the standard life table array into the third or fourth column of the projection table depending on the definition of the sex code. The CALL statement must be of the form:

CALL LSR (NSEX)

where NSEX is the sex code (1 = female, 2 = male).

3. Subroutine LPOP. LPOP loads a population distribution (5-year groups) present in a 21-word array (floating point) into column 1 or 2 depending on the definition of the sex code. The CALL statement must be of the form:

CALL LPOP (ARRAY, NSEX)

where ARRAY is the name of a previously dimensioned floating point array containing a male or female population distribution and NSEX is the sex code (1 = female, 2 = male).

4. Subroutine LPT. LPT is a meta-subroutine. It contributes nothing but a higher level organization of other subroutines. LPT obtains and loads not only male and female stable population percent age distributions into the first two columns of the projection table but also the sets of survival ratios (corresponding to the average life expectancy of the 5-year projection interval) into the third and fourth columns. The CALL statement must be of the form:

CALL LPT (EM, EF, R, NREGM, NREGF, STEP)

CALL statement arguments (all are inputs):

EM, EF. Life expectancies at birth at the starting point of the projection for males and females, respectively. The values of EM and EF are returned to the calling program with an increment of STEP multiplied by 2.5.

R. Rate of natural increase for both sexes at the starting point of the projection. R is expressed of unit basis (1% = .010).

NREGM, NREGF. Model life table regions for males and females, respectively.

STEP. Average annual increment to life expectancy for the 5-year interval.

Note that the floating point variables EM, EF, R, and STEP when entered as constants must have a decimal point. A glance at the listing of LPT in part V should remove any confusion about what LPT does and how. LPT will be useful in the preparation of quasi-stable projections. To convert percent distributions in columns 1 and 2 to absolute distributions, see part III, C7. Note that LPT calls LSP and, therefore, male and female birth rates are placed in rows 4 and 5 of column 9 (life table array) respectively.

5. Subroutine LMFP. LMFP loads fertility schedules based on any one of eight model fertility patterns into rows 4 to 10 of column 5 of the standard projection table. These fertility patterns are taken from U.N. Population Bulletin No. 7.[6] The reader is referred to this source for a complete explanation of the model fertility patterns. The fertility patterns are expressed as percentages summing to 100 across the 5-year age groups between 15 and 49. By converting the percentages to proportions and multiplying each by a predetermined total fertility rate (divided by five) a fertility schedule is obtained. The CALL statement must be of the form:

CALL LMFP (N,TFR)

where TFR is the desired total fertility rate (TFR must have a decimal point if entered as a constant) and N is a code (1 to 8) indicating one of the eight model fertility patterns. The codes are as follows:

Low fertility patterns	Early peak		1
	Broad peak		2
	Late peak		3
High fertility patterns	Early peak	type A	4
		type B	5
	Broad peak		6
	Late peak	type A	7
		type B	8

[6]Conditions and trends of fertility in the world, 1963, chapter 7. Sales No.: 66.XIII.4.

6. **Subroutine LMFPX.** Subroutine LMFPX is similar to subroutine LMPF. LMFPX uses LMFP to load a model fertility schedule into rows 4 through 10 of column 5 of the projection table. The fertility schedule loaded will be reconciled with a specified crude birth rate representing the midpoint of the 5-year projection cycle. All of the other projection table inputs required for projection must be present in the projection table before LMFPX is called. The required form of the CALL statement is:

CALL LMFPX (N, CBR)

where N is a model fertility pattern code (see part III, C5), and CBR is a crude birth rate (unit basis). (CBR must have a decimal point if entered as a constant.) Note the utility of entering a weighted average of male and female stable population birth rates as CBR in a call to LMFPX. This will establish a fertility schedule reconciled with these stable populations. See part III, C1 and part IV, case 6, line 12.

7. **Subroutine CPT.** When percent distributions are present in columns one and two of the standard projection table, they can be converted to numerical distributions with a call to CPT. The CALL statement must be of the form:

CALL CPT (TM,TF)

where TM is the total population for males and TF is the total for females. If entered as constants, TM and TF must have decimal points. An overall sex ratio of TM/TF is, of course, implied. The resulting age distributions in absolute form when associated with sets of survival ratios in turn imply a sex ratio at birth which may not be tenable if CPT is used carelessly. Subroutines PART and SR have been designed to assist the user with these problems.

8. **Subroutine PART.** PART partitions a given population total into a male and a female component in accord with a given sex ratio. The required form of the CALL statement is:

CALL PART (OSR,T,TM,TF)

where the call statement arguments are as follows:

OSR: Overall sex ratio, unit basis (input)
T: Population total (input)
TM: Total male population (output)
TF: Total female population (output)

9. **Subroutine SR.** SR can be used only if the projection table is loaded as follows.

Columns 1 and 2: Age distributions, percent form.

Columns 3 and 4: Survival ratios corresponding to the same point in time as the age distribution in columns 1 and 2.

If these conditions are met and the sex ratio at birth is known, SR will calculate the overall sex ratio (which can be used when calling PART). The required form of the CALL statement is:

CALL SR (SRB, OSR)

where SRB is the sex ratio at birth, unit basis (input) and OSR is the overall sex ratio, unit basis (output).

For stable populations, subroutine LPT (with STEP set to zero) can be used to load the first four columns of the projection table prior to calling SR. For an example of the use of CPT, PART, and SR, see part IV, case 6.

10. **Subroutine PROJ.** Once the required inputs have been loaded into the standard projection table, a call to PROJ will project the population distributions present in columns 1 and 2 for 5 years. The results will be placed in the appropriate row positions of columns 6 and 7 respectively. PROJ then applies the annual fertility rates for each 5-year age group between 15 and 49 (present in column 5 of the projection table) to the average number of women in each age group during the 5-year interval. The cumulated results (which represent an average annual cohort of births for the 5-year period) are multiplied by five, partitioned with the sex ratio at birth (present in row 1, column 5), and survived. If no sex ratio at birth is specified, a ratio of 1.05 will be used. The survivors of the 5-year male and female birth cohort are placed in row 1 of columns 6 and 7 respectively. PROJ also places a selection of summary statistics of the 5-year projection interval in column 8. See diagram 2 for the positions and descriptions of these statistics. The CALL statement must be of the form:

CALL PROJ

In order to continue the projection, the contents of columns 6 and 7 must first be transferred to columns 1 and 2. Subroutine T67 accomplishes this transfer (see part III, C11). If changes of fertility or mortality are desired for the next 5-year projection cycle, these also must be introduced prior to the next call to PROJ. Calls to the output subroutines described below related to PROJ should be made prior to the call to T67. See part IV, case studies 5 and 6.

11. **Subroutine T67.** T67 simply transfers the contents of the sixth and seventh projection table columns (the projected population from the previous cycle) to columns 1 and 2 in preparation for the next projection cycle. The CALL statement must be of the form:

CALL T67

12-15. **Projection Output Subroutines.** A table of output subroutines related to projection is presented in place of a separate description of each subroutine.

	Subroutine Name	Function	Form of CALL Statement
12.	PTP	Prints totals and percents	CALL PTP
13.	PT	Prints totals	CALL PT
14.	PP	Prints percents	CALL PP
15.	PTAB	Prints projection table	CALL PTAB (NROW)[7]

All of these subroutines (except PTAB) deal with the population at the beginning of the 5-year projection cycle. Calls to these subroutines must preceed the call to T67. In the event of malfunction, a call to PTAB will reveal the contents of the entire projection table. Other output options can be developed by selecting from the statistics in column 8 (see diagram 2) and using a WRITE statement. Sample output of each of these subroutines is shown in tables 3 through 6.

[7] NROW specifies the number of rows to be printed, a positive number not greater than 21.

Table 3. Sample Output for Subroutine PTP

Age[1]	Both sexes	Male	Female	Percent both sexes	Percent male	Percent female
All ages	100000.	50472.	49528.	100.00	100.00	100.00
0-4	11108.	5665.	5443.	11.11	11.22	10.99
5-9	9930.	5069.	4861.	9.93	10.04	9.81
10-14	9303.	4751.	4552.	9.30	9.41	9.19
15-19	8727.	4459.	4269.	8.73	8.83	8.62
20-24	8139.	4156.	3983.	8.14	8.23	8.04
25-29	7560.	3857.	3703.	7.56	7.64	7.48
30-34	7011.	3575.	3436.	7.01	7.08	6.94
35-39	6484.	3302.	3182.	6.48	6.54	6.42
40-44	5969.	3032.	2937.	5.97	6.01	5.93
45-49	5456.	2756.	2700.	5.46	5.46	5.45
50-54	4926.	2468.	2458.	4.93	4.89	4.96
55-59	4357.	2157.	2200.	4.36	4.27	4.44
60-64	3719.	1813.	1906.	3.72	3.59	3.85
65-69	2989.	1431.	1558.	2.99	2.84	3.15
70-74	2169.	1017.	1152.	2.17	2.02	2.33
75-79	1323.	605.	719.	1.32	1.20	1.45
80+	830.	360.	470.	0.83	0.71	0.95

[1] Tables 3-6 were generated with the following program:

```
COMMON A(21,9),B(21,8),C(51)
CALL LPT(50.,52.,.010,4,4.0.)
CBR = (A(4,9)+A(5,9))/2.
CALL LMFPX(6,CBR)
T=100000.
SRB=1.05
CALL SR(SRB,OSR)
CALL PART(OSR,T,TM,TF)
CALL CPT(TM,TF)
CALL PROJ
CALL PTP
CALL PT
CALL PP
CALL PTAB(21)
STOP
END
```

Table 4. Sample Output for Subroutine PT

Age[1]	Both sexes	Male	Female
All ages	100000.	50472.	49528.
0-4	11108.	5665.	5443.
5-9	9930.	5069.	4861.
10-14	9303.	4751.	4552.
15-19	8727.	4459.	4269.
20-24	8139.	4156.	3983.
25-29	7560.	3857.	3703.
30-34	7011.	3575.	3436.
35-39	6484.	3302.	3182.
40-44	5969.	3032.	2937.
45-49	5456.	2756.	2700.
50-54	4926.	2468.	2458.
55-59	4357.	2157.	2200.
60-64	3719.	1813.	1906.
65-69	2989.	1431.	1558.
70-74	2169.	1017.	1152.
75-79	1323.	605.	719.
80+	830.	360.	470.

Table 5. Sample Output for Subroutine PP

Age[1]	Percent both sexes	Percent male	Percent female
All ages	100.00	100.00	100.00
0-4	11.11	11.22	10.99
5-9	9.93	10.04	9.81
10-14	9.30	9.41	9.19
15-19	8.73	8.83	8.62
20-24	8.14	8.23	8.04
25-29	7.56	7.64	7.48
30-34	7.01	7.08	6.94
35-39	6.48	6.54	6.42
40-44	5.97	6.01	5.93
45-49	5.46	5.46	5.45
50-54	4.93	4.89	4.96
55-59	4.36	4.27	4.44
60-64	3.72	3.59	3.85
65-69	2.99	2.84	3.15
70-74	2.17	2.02	2.33
75-79	1.32	1.20	1.45
80+	0.83	0.71	0.95

Table 6. **Sample Output for Subroutine PTAB**

1	5665.	5443.	.83511	.84258	1.0500	5891.	5691.	0.0
2	5069.	4861.	.94115	.93927	0.0	5331.	5113.	13772.40
3	4751.	4552.	.98531	.98441	0.0	4994.	4785.	9109.00
4	4459.	4269.	.98664	.98587	0.0660	4687.	4437.	50472.00
5	4156.	3983.	.97986	.98099	0.1758	4369.	4187.	49528.05
6	3857.	3703.	.97568	.97742	0.1810	4055.	3893.	52853.89
7	3575.	3436.	.97431	.97547	0.1476	3758.	3613.	51809.55
8	3302.	3182.	.97117	.97344	0.1090	3472.	3345.	102331.69
9	3032.	2937.	.96523	.97041	0.0482	3187.	3088.	0.02692
10	2756.	2700.	.95574	.96622	0.0141	2898.	2838.	0.01780
11	2468.	2458.	.94127	.95722	0.0	2595.	2584.	0.00911
12	2157.	2200.	.91876	.94093	0.0	2268.	2313.	0.0
13	1813.	1906.	.88348	.91074	0.0	1906.	2004.	0.0
14	1431.	1558.	.82989	.85923	0.0	1504.	1638.	0.0
15	1017.	1152.	.74717	.77712	0.0	1069.	1211.	0.0
16	605.	719.	.62506	.65615	0.0	636.	756.	0.0
17	360.	470.	.38795	.41032	0.0	235.	295.	0.0

Note: See diagram 2 for location definitions. Also, see footnote to table 3.

IV. Case Studies

CASE 1. Construct and print a model, west, male life table with a life expectancy at birth of 50.0 years.

```
Line  Instruction
 1    CALL MLT(50.0,2,1)
 2    CALL PLT(18)
 3    STOP
 4    END
```

Line Comments

1 Places the specified life table in the standard life table array.

2 Prints 18 rows of the standard life table array. Column 9 is not printed.

– The standard COMMON statement is not required in the main program because no manipulations of the standard arrays are carried out within the main program.

DCL subroutines which must be included: MLT, MLTX, PLT.
Output. one life table. See description of subroutine PLT for sample format.

CASE 2. Construct and print a model, south, male life table corresponding to the female, model, south life table with life expectancy at birth of 50.0 years.

```
Line  Instruction
 1    COMMON D(21,9), TAB(21,8), E(51)
 2    CALL MLT(50.0,1,4)
 3    CALL MLTX(D(2,9),2,4)
 4    CALL PLT(18)
 5    STOP
 6    END
```

Line Comments

1 Standard COMMON statement must be present whenever the main program makes direct use of any of the standard arrays. Note the call to MLTX, line 3.

2 Places female life table in the standard life table array. The control variable for the opposite sex is computed and placed in D(2,9). See description of MLTX.

3 Places male life table in the standard life table array.

4 Eighteen rows (excluding column 9) of the current contents of the standard life table array (in this case, the male life table) are printed.

DCL subroutines which must be included: MLT, MLTX, PLT.
Output: one life table.

CASE 3. Print a male life table constructed form a given set of M_x values using the Reed-Merrell method for M_x-Q_x conversion.

```
Line  Instruction
 1    DIMENSION EMX(21)
 2    DATA EMX/.18933,.02838,.00381,.00372,
      3& .00693,.00903,.00928,.00964,.01037,.01154,
      4& .01275,.01609,.02255,.02949,.04712,.06388,
      5& 5*0.0/
 6    CALL MXQX(EMX, 2)
 7    CALL ELT(2)
 8    CALL PLT(17)
 9    STOP
10    END
```

Line Comments

1 It is necessary that the array containing the M_x values be dimensioned 21 regardless of the actual number of M_x values in the set concerned.

2 A set of M_x values are entered into array EMX with this DATA statement.

6 This call converts the M_x values to Q_x values. The Q_x values are placed in column 1 of the life table array.

7 With Q_x values already in place, this call to ELT will complete the life table.

8 Sixteen M_x values were entered and subroutine MXQX adds another Q_x value (set to 1.0).

DCL subroutines which must be included: MXQX, ELT, PLT.
Output: one life table.

CASE 4. Generate a stable population with a model, east, male life table with a life expectancy at birth of 37.2 years and a rate of natural increase of .020. Print the stable population parameters with labels.

```
Line  Instruction
 1    CALL MLT(37.2,2,3)
 2    CALL SPP(.020)
 3    CALL PSPP
 4    STOP
 5    END
```

Line Comments
1-3 See subroutine descriptions for details.

DCL subroutines which must be included: MLT, MLTX, SPP, PSPP.
Output: a selection of stable population parameters. See description of subroutine PSPP.
Output can be checked with Coale-Demeny volume op. cit. p.574.

CASE 5. Project male and female stable population structures (life expectancies at birth: male = 50.0, female = 52.0; region is south and rate of natural increase is .010 for both sexes) 25 years into the future using constant mortality and fertility (model fertility pattern 6, total fertility rate = 6.4). Sex ratio at birth is 1.05 and constant. No migration. Print percent age distributions for the starting points of each 5-year projection cycle.

```
Line  Instruction
 1    COMMON A(21,9), B(21,8), C(51)
 2    CALL LPT(50.,52.,.010,4,4,0.)
 3    CALL LMFP(6,6.4)
 4    B(1,5)=1.05
 5    DO 2 I=1,5
 6    CALL PROJ
 7    CALL PP
 8    2 CALL T67
 9    STOP
10    END
```

Line Comments

2 This CALL causes the first four columns of the standard projection array (in this case, array B) to be loaded.

3-4 These CALLs cause column 5 of the standard projection array to be loaded. (Note that use of the total fertility rate does not quarantee a birth rate reconciled with the birth rates of the stable populations. See case 6.)

6 This CALL: (1) projects columns 1 and 2 for 5 years, (2) computes, partitions, and survives a 5-year birth cohort, and (3) calculates the selected statistics of column 8. The results are placed in the positions of the standard projection array indicated in diagram 2.

8 After each 5-year projection cycle, the new population distributions (columns 6 and 7) are placed in the source population columns (1 and 2) in preparation for the next projection cycle.

DCL subroutines which must be included: LPT, MLT, MLTX, SPP, LSP, LSR, LMFP, PROJ, T67.
Output: five sets of percent age distributions. See sample output for subroutine PP above.

CASE 6. Project male and female model stable populations (e_{om} = 50.0, e_{of} = 52.0, South region for both sexes, rate of natural increase = .010) 25 years into the future using constant fertility (model fertility pattern 6). Reconcile birth rate with those of the stable populations. Mortality is declining at the rate of .75 years increment to life expectancy per year. Initial total population is 15,000. Sex ratio at birth is 1.05 and constant. No migration. Print the age distributions (totals and percents) for the starting points of each 5-year projection cycle.

```
Line  Instruction
 1    COMMON A(21,9),B(21,8),C(51)
 2    T=15000
 3    EM=50.0
 4    EF=52.0
 5    STEP=.75
 6    B(1,5)=1.05
 7    CALL LPT(EM,EF,.010,4,4,0.)
 8    CALL SR(B(1,5),OSR)
 9    CALL PART(OSR,T,TM,TF)
10    CALL LPT (EM,EF,.010,4,4,STEP)
11    CALL CPT(TM,TF)
12    CBR=(A(4,9)*TM+A(5,9)*TF)/T
13    CALL LMFPX(6,CBR)
14    DO 2 I=1,5
15    CALL PROJ
16    CALL PTP
17    EM=EM+STEP*5.
18    EF=EF+STEP*5.
19    CALL MLT(EM,2,4)
20    CALL LSR(2)
21    CALL MLT(EF,1,4)
22    CALL LSR(1)
23    2 CALL T67
24    STOP
25    END
```

Line Comments

8 With the first four columns of the projection table loaded, SR calculates the overall sex ratio implied by the sex ratio at birth.

9 PART partitions the given population total by means of the overall sex ratio obtained from SR.

10 LPT must be called again here to load the survival ratios appropriate for projection.

12 A weighted average of the stable population birth rates is obtained here to be used as input to the following instruction. (See part III C1 and C6.)

17-22 Male and female life expectancies at birth are incremented, new life tables generated, and the new survival ratios loaded into columns 3 and 4 of the standard projection array prior to a call to T67 and the next call to PROJ.

DCL subroutines which must be included: LPT, MLT, MLTX, SPP, LSP, LSR, LMFP, PROJ, T67, LMFPX, PTP, SR, PART.
Output: five tables. See sample output of PTP for format.

V. Program Listings

(alphabetical order, IBM 360)

```
      SUBROUTINE CPT(TM,TF)
      COMMON D(21,9), TAB(21,8), E(51)
      DO 4 I=1,21
      TAB(I,1)=TAB(I,1)*TM/100.
    4 TAB(I,2)=TAB(I,2)*TF/100.
      RETURN
      END
```

```
      SUBROUTINE ELT(NSEX)
      COMMON TAB(21,9),TDUMY(21,8),E(51)
      DIMENSION K(6,2)
      REAL K,KZ,K1
      DATA K/.35,.05,3.,1.361,1.524,1.625,.33,.0425,2.875,1.352,1.653,
     13.C13/
      IF (TAB(1,1).LT.0.1) GO TO 22
      KZ=K(1,NSEX)
      K1=K(4,NSEX)
      GO TO 23
   22 KZ=K(2,NSEX)+K(3,NSEX)*TAB(1,1)
      K1=K(5,NSEX)-K(6,NSEX)*TAB(1,1)
   23 CONTINUE
      TAB(1,4)=100000.
      DO 30 I=1,21
      TAB(I,2)=TAB(I,4)*TAB(I,1)
   30 TAB(I+1,4)=TAB(I,4)-TAB(I,2)
      TAB(1,5)=KZ*TAB (1,4)+(1.-KZ)*TAB(2,4)
      TAB(2,5)=K1*TAB (2,4)+(4.-K1)*TAB(3,4)
      DO 14 I=4,21
      IF(TAB(I,4)) 4,4,14
   14 TAB(I-1,5)=(TAB(I-1,4)+TAB(I,4))/2.*5.
      N=I
      GO TO 16
    4 N=I-1
   16 CONTINUE
      TAB(N,5)=TAB(N,4)*ALOG (TAB(N,4))/ALOG(10))
      TAB(N,7)=TAB(N,5)
      N2=N-1
      DO 60 I=1,N2
      J=N-I
   60 TAB(J,7)=TAB(J+1,7)+TAB(J,5)
      DO 66 I=1,N
   66 TAB(I,8)=TAB(I,7)/TAB(I,4)
      DO 68 I=3,N2
   68 TAB(I,6)=TAB(I+1,5)/TAB(I,5)
      TAB(1,6)=(TAB(1,5)+TAB(2,5))/(TAB(1,4)*5.)
      TAB(2,6)=TAB(3,5)/(TAB(1,5)+TAB(2,5))
      DO 607 I=1,N
  607 TAB(I,3)=TAB(I,2)/TAB(I,5)
      RETURN
      END
```

```
      SUBROUTINE LMFP(L,TFR)
      COMMON D(21,9),TAB(21,8),E(51)
      DIMENSION F(7,8)
      DATA F/
     1.117,.361,.270,.148,.076,.026,.003,
     1.059,.304,.307,.193,.100,.034,.003,
     1.034,.229,.319,.228,.135,.049,.005,
     1.162,.247,.219,.174,.118,.058,.023,
     1.125,.285,.251,.178,.112,.040,.009,
     1.089,.237,.244,.199,.147,.065,.019,
     1.051,.229,.288,.226,.145,.050,.010,
     1.056,.194,.246,.233,.172,.084,.014/
      DO 6 I=1,7
    6 TAB(I+3,5)=F(I,L)*TFR/5.
      RETURN
      END


      SUBROUTINE LMFPX(N,CBR)
      COMMON A(21,9),B(21,8),C(51)
      TFR1=2
      TFR2=7
      CALL LMFP(N,TFR1)
      CALL PROJ
      CRB1=B(9,8)
      CALL LMFP(N,TFR2)
      CALL PROJ
      CBR2=B(9,8)
      TFR=TFR1+(CBR-CBR1)/(CBR2-CBR1)*(TFR2-TFR1)
      DO 5 I=1,10
      CALL LMFP(N,TFR)
      CALL PROJ
      GAP=B(9,8)-CBR
      GAP=ABS(GAP)
      IF(GAP.LT..0001) GO TO 8
      TFR=TFR+(CBR-B(9,8))/(CBR2-B(9,8))*(TFR2-TFR)
    5 CONTINUE
    8 RETURN
      END


      SUBROUTINE LPOP(POP,NSEX)
      COMMON D(21,9),TAB(21,8),E(51)
      DIMENSION POP(21)
      N=2/NSEX
      DO 2 I=1,21
    2 TAB(I,N)=POP(I)
      RETURN
      END
```

```
      SUBROUTINE LPT(EM,EF,R,NREGM,NREGF,STEP)
      COMMON D(21,9),TAB(21,8),E(51)
      CALL MLT(EF,1,NREGF)
      CALL SPP(R)
      CALL LSP(1)
      EF=EF+STEP*2.5
      CALL MLT(EF,1,NREGF)
      CALL LSR(1)
      CALL MLT(EM,2,NREGM)
      CALL SPP(R)
      CALL LSP(2)
      EM=EM+STEP*2.5
      CALL MLT(EM,2,NREGM)
      CALL LSR(2)
      RETURN
      END


      SUBROUTINE LSP(N)
      COMMON D(21,9),TAB(21,8),E(51)
      NSEX=N
      NSEX=2/NSEX
      DO 30 I=1,17
   30 TAB(I,NSEX)=E(I+5)
      TAB(1,NSEX)=TAB(1,NSEX)+E(5)
      IF (NSEX.EQ.1) D(4,9)=E(39)
      IF (NSEX.EQ.2) D(5,9)=E(39)
      RETURN
      END


      SUBROUTINE LSR(N)
      COMMON D(21,9),TAB(21,8),E(51)
      NSEX=N
      NSEX=2/NSEX+2
      DO 10 I=1,21
   10 TAB(I,NSEX)=D(I,6)
      RETURN
      END
```

```
      SUBROUTINE MLT(EO,SEX,REG)
      INTEGER SEX,REG
      COMMON D(21,9),TAB(21,8),E(51)
      DIMENSION B(2,2,4)
      DATA B/3.37,.870,7.80,.834,5.84,.818,8.79,.799,16.14,.703,22.23,
     1.642,14.26,.796,15.41,.782/
      K=SEX
      L=REG
      N=1
      U=100.0
      V=100.0
      W=0.0
      Q=0.0
      ET=B(1,K,L)+B(2,K,L)*EO
      CALL MLTX(ET,K,L)
   10 X=EO-D(1,8)
      Y=ABS(X)
      IF(Y-.001) 13,13,40
   40 CONTINUE
      IF(X) 11,45,45
   45 CONTINUE
      W=ET
      Q=D(1,8)
   12 ET=(U-W)*(EO-Q)/(V-Q)+W
      CALL MLTX(ET,K,L)
      N=N+1
      GO TO 10
   11 U=ET
      V=D(1,8)
      GO TO 12
   13 D(3,9)=N
      RETURN
      END
```

```
      SUBROUTINE MLTX(ET,SEX,REG)
      COMMON D(21,9),TAB(21,8),CDUM(51)
C MLTX GENERATES LIFE TABLE FROM DUMMY VARIABLE E(10)
C THE METHODOLOGY IS SET FORTH IN COALE&DEMENY"REGIONAL MODEL LIFE TABLES
      DIMENSION B(2,2,4,2),A(4,17,2,4),C(2,2,4,2),E(2,2,4)
      DIMENSION AIJ11(68),AIJ21(68),AIJ12(68),AIJ22(68)
      DIMENSION AIJ13(68),AIJ23(68),AIJ14(68),AIJ24(68)
      DIMENSION T(4,4)
      INTEGER SEX,REG
      DATA T/55.749,58.540,4.604,5.046,53.922,56.622,5.911,6.112,
     154.064,56.664,4.682,5.883,53.054,55.590,4.755,5.601/
      DATA B/0.35,0.0,0.33,0.0,0.35,0.0,0.33,0.0,0.31,0.0,0.29,0.0,0.35,
     10.0,0.33,0.0,0.05,3.0,0.0425,2.875,0.05,3.0,0.0425,2.875,0.01,3.0,
     2.0025,2.875,0.05,3.0,0.0425,2.875/
      DATA C/1.361,0.0,1.352,0.0,1.570,0.0,1.558,0.0,1.324,0.0,1.313,0.0
     1,1.239,0.0,1.240,0.0,   1.524,1.625,1.653,3.013,1.733,1.627,1.859,
     23.013,1.402,1.627,1.541,3.013,1.487,1.627,1.614,3.013/
      DATA Z/1.0/
      DATA  AIJ11/
     10.53774,0.008044,5.8992,0.05406,
     20.39368,0.006162,7.4576,0.08834,
     30.10927,0.001686,6.2018,0.07410,
     40.08548,0.001320,5.9627,0.07181,
     50.10979,0.001672,5.9335,0.06812,
     60.13580,0.002051,5.9271,0.06577,
     70.15134,0.002276,5.8145,0.06262,
     80.17032,0.002556,5.6578,0.05875,
     90.18464,0.002745,5.3632,0.05232,
     A0.19390,0.002828,4.9600,0.04380,
     B0.20138,0.002831,4.5275,0.03436,
     C0.25350,0.003487,4.4244,0.03004,
     D0.31002,0.004118,4.3131,0.02554,
     E0.43445,0.005646,4.3439,0.02295,
     F0.53481,0.006460,4.2229,0.01773,
     G0.69394,0.007713,4.1838,0.01376,
     H0.84589,0.008239,4.1294,0.00978/
      DATA  AIJ21/
     10.63726,0.009958,5.8061,0.05338,
     20.40548,0.006653,7.1062,0.08559,
     30.10393,0.001662,5.4472,0.06295,
     40.07435,0.001183,5.0654,0.05817,
     50.09880,0.001539,4.8700,0.05070,
     60.14009,0.002183,5.0677,0.05156,
     70.15785,0.002479,5.2660,0.05471,
     80.18260,0.002875,5.3438,0.05511,
     90.21175,0.003312,5.2792,0.05229,
     A0.25049,0.003864,5.0415,0.04573,
     B0.27894,0.004158,4.6666,0.03637,
     C0.33729,0.004856,4.4506,0.02961,
     D0.38425,0.005190,4.2202,0.02256,
     E0.48968,0.006300,4.1851,0.01891,
     F0.59565,0.007101,4.1249,0.01491,
     G0.73085,0.007911,4.1051,0.01161,
     H0.89876,0.008695,4.1133,0.00895/
```

```
      DATA  AIJ12/
     10.47504,0.006923,5.7332,0.05133,
     20.45025,0.006805,7.6298,0.08909,
     30.19376,0.002928,7.1271,0.08647,
     40.10041,0.001497,6.1089,0.07192,
     50.10126,0.001480,5.4904,0.05955,
     60.11261,0.001618,5.2649,0.05372,
     70.13137,0.001893,5.2547,0.05236,
     80.15448,0.002239,5.3691,0.05339,
     90.17693,0.002566,5.3186,0.05136,
     A0.18440,0.002612,4.9099,0.04261,
     B0.19440,0.002712,4.6164,0.03627,
     C0.22364,0.003011,4.3673,0.02961,
     D0.30043,0.004053,4.4363,0.02858,
     E0.41033,0.005394,4.4163,0.02511,
     F0.56691,0.007187,4.4030,0.02152,
     G0.77206,0.009334,4.3826,0.01784,
     H0.96175,0.010681,4.3108,0.01355/
      DATA  AIJ22/
     10.54327,0.008251,5.6151,0.05022,
     20.46169,0.007290,7.2025,0.08475,
     30.18983,0.002974,6.1947,0.07195,
     40.09551,0.001476,5.3488,0.06047,
     50.09666,0.001422,4.5662,0.04322,
     60.13472,0.001968,4.6970,0.04277,
     70.14325,0.002103,4.7661,0.04372,
     80.15280,0.002244,4.7248,0.04236,
     90.17535,0.002589,4.7568,0.04197,
     A0.20924,0.003083,4.7280,0.03986,
     B0.24673,0.003605,4.6020,0.03578,
     C0.28578,0.004016,4.3499,0.02857,
     D0.36171,0.005037,4.3718,0.02682,
     E0.45849,0.006124,4.2977,0.02244,
     F0.59986,0.007677,4.2858,0.01913,
     G0.82662,0.010241,4.3482,0.01710,
     H1.03681,0.011906,4.3197,0.01357/
      DATA  AIJ13/
     10.78219,0.011679,5.8529,0.05064,
     20.46584,0.007284,7.2269,0.08351,
     30.13739,0.002136,6.3204,0.07590,
     40.07600,0.001166,5.6332,0.06684,
     50.10067,0.001529,5.5780,0.06295,
     60.13039,0.001973,5.5872,0.06081,
     70.15401,0.002335,5.6149,0.06004,
     80.16941,0.002559,5.4593,0.05616,
     90.18184,0.002718,5.1881,0.05000,
     A0.18555,0.002718,4.8186,0.04209,
     B0.19407,0.002746,4.4509,0.03368,
     C0.24415,0.003376,4.3702,0.02966,
     D0.34490,0.004723,4.4480,0.02807,
     E0.49585,0.006651,4.4917,0.02544,
     F0.68867,0.008874,4.4702,0.02152,
     G0.88452,0.010551,4.3759,0.01640,
     H1.07727,0.011513,4.2972,0.01191/
```

```
 DATA  AIJ23/
11.07554,0.017228,6.3796,0.06124,
20.55179,0.009201,7.8944,0.09934,
30.15292,0.002523,6.4371,0.08076,
40.06656,0.001096,5.1199,0.05978,
50.10060,0.001578,4.9229,0.05182,
60.14725,0.002312,5.1056,0.05225,
70.15127,0.002381,5.1036,0.05207,
80.17022,0.002686,5.1685,0.05244,
90.20786,0.003277,5.1986,0.05131,
A0.24876,0.003868,5.0221,0.04577,
B0.28685,0.004323,4.6915,0.03697,
C0.32623,0.004654,4.3492,0.02757,
D0.38906,0.005243,4.1849,0.02171,
E0.49337,0.006341,4.1647,0.01842,
F0.66168,0.008182,4.2175,0.01634,
G0.84168,0.009644,4.2171,0.01324,
H1.03876,0.010780,4.2155,0.01035/
 DATA  AIJ14/
10.52069,0.007051,4.5097,0.02566,
20.68268,0.010453,5.9815,0.05532,
30.17066,0.002657,5.6479,0.06136,
40.09900,0.001380,5.1045,0.05537,
50.12189,0.001851,5.2384,0.05494,
60.15083,0.002279,5.1708,0.05171,
70.16073,0.002412,5.0943,0.04945,
80.16719,0.002505,4.9291,0.04590,
90.17408,0.002583,4.8035,0.04280,
A0.17278,0.002504,4.4917,0.03615,
B0.17800,0.002513,4.2693,0.03092,
C0.22639,0.003140,4.1982,0.02717,
D0.30167,0.004130,4.2724,0.02588,
E0.47682,0.006501,4.4242,0.02491,
F0.67440,0.008891,4.4554,0.02190,
G0.92943,0.011532,4.4348,0.01775,
H1.16023,0.013009,4.3542,0.01296/
 DATA  AIJ24/
10.61903,0.008974,4.7096,0.02980,
20.70613,0.011375,6.3246,0.06433,
30.16455,0.002674,5.6400,0.06389,
40.07634,0.001207,4.6816,0.05008,
50.11449,0.001810,4.9454,0.05170,
60.17104,0.002693,5.2748,0.05458,
70.17171,0.002710,5.1168,0.05152,
80.16483,0.002535,4.8459,0.04547,
90.17905,0.002734,4.7660,0.04292,
A0.20606,0.003081,4.5796,0.03738,
B0.23208,0.003370,4.3559,0.03116,
C0.28000,0.003917,4.1918,0.02547,
D0.35245,0.004765,4.1492,0.02193,
E0.49465,0.006569,4.2479,0.02063,
F0.66947,0.008608,4.3069,0.01863,
G0.89759,0.010843,4.3251,0.01552,
H1.10111,0.011806,4.2684,0.01123/
```

```
      IF((SEX.NE.1).AND.(SEX.NE.2)) WRITE(3,57) SEX
      IF((SEX.NE.1).AND.(SEX.NE.2)) STOP
   57 FORMAT(1X,4HSEX=,I2,10H BAD CODE      )
      IF((REG.LT.1).OR.(REG.GT.4)) GO TO 48
      IF(ET) 48,48,49
   49 IF(ET-100)45,48,48
   48 WRITE(3,47) REG,ET
   47 FORMAT(1X,30H REG OR ET HAS BAD CODE REG =       I2, 3HET=  1F10.5)
      RETURN
   45 CONTINUE
      DO 60 J=1,17
      DO 60 I=1,4
      MS=(J-1)*4+I
      A(I,J,2,1)=AIJ21(MS)
      A(I,J,1,2)=AIJ12(MS)
      A(I,J,2,2)=AIJ22(MS)
      A(I,J,1,3)=AIJ13(MS)
      A(I,J,2,3)=AIJ23(MS)
      A(I,J,1,4)=AIJ14(MS)
      A(I,J,2,4)=AIJ24(MS)
   60 A(I,J,1,1)=AIJ11(MS)
      K=SEX
      L=REG
      D(18,1)=1.0
      D(1,9)=ET
      DO 10 J=1,17
      Y=A(1,J,K,L)-A(2,J,K,L)*ET
      X=A(3,J,K,L)-A(4,J,K,L)*ET
      IF(X .GT. 170.0) GO TO 100
      GO TO 13
  100 WRITE(3,101) ET, X, J
  101 FORMAT(5X,7HEVE EXP  F12.6,5X,F12.6,5X,I3)
      RETURN
   13 W=(10**X)/10000.0
      IF(W-Y)11,95,95
   95 IF(ET-54.0) 96,96,12
   96 D(J,1)=Y
      GO TO 10
   12 D(J,1)=W
      GO TO 10
   11 D(J,1)=(Y+W)/2.0
   10 CONTINUE
   20 D(1,4)=100000.0
      DO 21 J=2,18
      D(J-1,2)=D(J-1,4)*D(J-1,1)
   21 D(J,4)=D(J-1,4)-D(J-1,2)
      D(18,2)=D(18,4)
      IF(D(1,1)-0.1)23,52,52
   52 M=1
   24 BK=B(1,K,L,M)+B(2,K,L,M)*D(1,1)
      D(1,5)=BK*D(1,4)+(1.0-BK)*D(2,4)
      BK=C(1,K,L,M)-C(2,K,L,M) *D(1,1)
      D(2,5)=BK*D(2,4)+(4.0-BK)*D(3,4)
      GO TO 30
```

```
23 M=2
   GO TO 24
30 DO 31 J=3,17
31 D(J,5)=2.5 *(D(J,4)+D(J+1,4))
   D(18,8)=3.725+0.0000625*D(18,4)
   D(18,7)=D(18,8)*D(18,4)
   D(18,5)=D(18,7)
   DO 32 I=1,17
   J=18-I
32 D(J,7)=D(J+1,7)+D(J,5)
   DO 33 J=1,18
   D(J,8)=D(J,7)/ D(J,4)
33 D(J,3)=D(J,2)/D(J,5)
   DO 34 J=3,16
34 D(J,6)=D(J+1,5)/D(J,5)
   D(1,6)=(D(1,5)+D(2,5))/(5.0 * D(1,4))
   D(2,6)=D(3,5)/(D(1,5)+D(2,5))
   D(17,6)=D(18,7)/D(17,7)
   D(18,6)=0.0
   IF (SEX-1) 73,75,73
75 D(2,9)=T(1,REG)+(T(3,REG)/T(4,REG))*(ET-T(2,REG))
   GO TO 77
73 D(2,9)=(ET-T(1,REG))*T(4,REG)/T(3,REG)+T(2,REG)
77 RETURN
   END
```

```
      SUBROUTINE MXQX(EMX,NSEX)
      COMMON TAB(21,9),TDUMY(21,8),E(51)
      DIMENSION EMX(21)
      DIMENSION K(6,2)
      REAL K,K1
      DATA K/.35,.05,3.,1.361,1.524,1.625,.33,.0425,2.875,1.352,1.653,
     13.013/
      IF (TAB(1,1).LT.0.1) GO TO 22
      K1=K(4,NSEX)
      GO TO 23
   22 CONTINUE
      K1=K(5,NSEX)-K(6,NSEX)*TAB(1,1)
   23 CONTINUE
      TAB(1,1)=EMX(1)
      TAB(2,1)=4*EMX(2)/(1.+(4.-K1)*EMX(2))
      CON=.008*5.**3
      DO 3 I=3,21
      IF (EMX(I).LT..00001) GO TO 4
    3 TAB(I,1)=1.-EXP(EMX(I)*(-5)-CON*EMX(I)**2)
    4 TAB(I,1)=1.0
      RETURN
      END


      SUBROUTINE  PART(USR,T,TM,TF)
      TM=T*USR/(USR+1.)
      TF=T-TM
      RETURN
      END


      SUBROUTINE PLT(NROW)
      COMMON D(21,9),TAB(21,8),E(51)
      WRITE(3,131)
  131 FORMAT(///4X,'AGE     Q(X)     D(X)     M(X)     1(X)     L(X)     P(X)'
     1'    T(X)    E(X)'//)
      DO 30 I=1,NROW
      IF(I .EQ. 1) KT5=0
      IF(I .EQ. 2) KT5=1
      IF(I .GE. 3) KT5=(I-2) * 5
   30 WRITE(3,7) KT5,   (D(I,J),J=1,8)
    7 FORMAT (4X,I3,2X,F7.5,1X,F6.0,1X,F6.5,1X,F7.0,1X,F7.0,
     11X,F6.5,1X,F8.0,1X,F5.2)
      RETURN
      END
```

```
      SUBROUTINE PP
      COMMON D(21,9),TAB(21,8),E(51)
      DIMENSION KTAB(21,2),TTX(21),       TMX(21),TFX(21),TOT(21)
      DATA MINUS/4H-   -/
      DATA PLUS/4H+   +/
      DO 71 K=1,21
      KTAB(K,1)=K*5-5
   71 KTAB(K,2)=K*5-1
      DO 62 I=1,21
   62 TOT(I)=TAB(I,1)+TAB(I,2)
      TT=0.
      TT=TAB(4,8)+TAB(5,8)
      DO 68 I=1,21
      TTX(I)=TOT(I)/TT*100.
      TMX(I)=TAB(I,1)/TAB(4,8)*100.
   68 TFX(I)=TAB(I,2)/TAB(5,8)*100.
      TP=0.
      TMP=0.
      TFP=0.
      DO 27 I=1,21
      TP=TP+TTX(I)
      TMP=TMP+TMX(I)
   27 TFP=TFP+TFX(I)
      WRITE(3,6)
    6 FORMAT(1H )
      WRITE(3,4)
    4 FORMAT(2X,'AGE',5X,'% BOTH',2X,'% MALE',2X,'% FEMALE')
      WRITE(3,101)
  101 FORMAT (10X,'SEXES')
      WRITE(3,6)
      WRITE(3,117)
  117 FORMAT(2X,'ALL')
      WRITE(3,17)  TP,TMP,TFP
   17 FORMAT(2X,'AGES',4X,F6.2,2X,F6.2,3X,F6.2)
      WRITE(3,6)
      DO 18 I=1,21
      IF(TTX(I+1)) 10,10,7
   10 WRITE(3,99)  KTAB(I,1),PLUS,TTX(I), TMX(I),TFX(I)
      WRITE(3,6)
      GO TO 5
   99 FORMAT (2X,I3,2X,A1,2X,F6.2,2X,F6.2,3X,F6.2)
    7 CONTINUE
   18 WRITE(3,2)  KTAB(I,1),MINUS,KTAB(I,2),TTX(I),TMX(I),TFX(I)
    2 FORMAT (2X,I3,A1,I3,1X,F6.2,2X,F6.2,3X,F6.2)
    5 RETURN
      END
```

```
      SUBROUTINE PROJ
      COMMON D(21,9),TAB(21,8),E(51)
      DO 8 I=2,21
      TAB(I,6)=TAB(I-1,1)*TAB(I,3)
    8 TAB(I,7)=TAB(I-1,2)*TAB(I,4)
      TAB(2,8)=0.
      DO 6 I=4,10
    6 TAB(2,8)=TAB(2,8)+(TAB(I,2)+TAB(I,7))/2.*TAB(I,5)
      TAB(2,8)=TAB(2,8)*5.
      IF(TAB(1,5).LT..01) TAB(1,5)=1.05
      TAB(1,6)=TAB(2,8)*TAB(1,5)/(TAB(1,5)+1.)
      TAB(1,7)=TAB(2,8)-TAB(1,6)
      TAB(1,6)=TAB(1,6)*TAB(1,3)
      TAB(1,7)=TAB(1,7)*TAB(1,4)
      TAB(3,8)=0.
      DO 53 I=1,20
   53 TAB(3,8)=TAB(3,8)+(TAB(I,1)-TAB(I+1,6))+(TAB(I,2)-TAB(I+1,7))
      TAB(3,8)=TAB(3,8)+TAB(21,1)+TAB(21,2)
      TAB(3,8)=TAB(3,8)+TAB(2,8)-(TAB(1,6)+TAB(1,7))
      TM=0.
      TF=0.
      DO 73 I=1,21
      TM=TM+TAB(I,1)
   73 TF=TF+TAB(I,2)
      TAB(4,8)=TM
      TAB(5,8)=TF
      TAB(6,8)=0.
      TAB(7,8)=0.
      DO 87 I=6,7
      DO 87 J=1,21
   87 TAB(I,8)=TAB(I,8)+TAB(J,I)
      TAB(8,8)=(TAB(4,8)+TAB(5,8)+TAB(6,8)+TAB(7,8))/2.
      TAB(9,8)=(TAB(2,8)/5.)/TAB(8,8)
      TAB(10,8)=(TAB(3,8)/5.)/TAB(8,8)
      TAB(11,8)=TAB(9,8)-TAB(10,8)
      RETURN
      END
```

```
      SUBROUTINE PSPP
      COMMON U(21,9),TAB(21,8),E(51)
      DIMENSION ND(141)
      DIMENSION NDX(153)
      DATA ND/
     14H    ,4H 0-1,4H    ,4H    ,4H 1-4,4H    ,4H    ,4H 5-9,4H    ,
     14H   1,4H0-14,4H    ,4H   1,4H5-19,4H    ,4H   2,4H0-24,4H    ,
     14H   2,4H5-29,4H    ,4H   3,4H0-34,4H    ,4H   3,4H5-39,4H    ,
     14H   4,4H0-44,4H    ,4H   4,4H5-49,4H    ,4H   5,4H0-54,4H    ,
     14H   5,4H5-59,4H    ,4H   6,4H0-64,4H    ,4H   6,4H5-69,4H    ,
     14H   7,4H0-74,4H    ,4H   7,4H5-79,4H    ,4H   8,4H0 + ,4H    ,
     14H   T,4HOTAL,4H    ,4H    ,4H   1,4H    ,4H    ,4H   5,4H    ,
     14H    ,4H  10,4H    ,4H    ,4H  15,4H    ,4H    ,4H  20,4H    ,
     14H    ,4H  25,4H    ,4H    ,4H  30,4H    ,4H    ,4H  35,4H    ,
     14H    ,4H  40,4H    ,4H    ,4H  45,4H    ,4H    ,4H  50,4H    ,
     14H    ,4H  55,4H    ,4H    ,4H  60,4H    ,4H    ,4H  65,4H    ,
     14H  TO,4HTAL ,4H    ,
     14H BIR,4HTH R,4HATE ,4H DEA,4HTH R,4HATE ,
     14H  GR,4HR(27,4H)   ,4H  GR,4HR(29,4H)   ,
     14H  GR,4HR(31,4H)   ,4H  GR,4HR(33,4H)   ,4H AVE,
     14HRAGE,4H AGE,4H PRO,4HP.15,4H-44 ,
     14H BR.,4H/P.1,4H5-44,4H POP,4H-4/1,4H5-44,4H POP,
     14H.5-1,4H4/5+,4H DEP,4H RAT,4HIO  ,4H P.S,4HZ.B(,
     14HO)=1/
      DO 12 I=1,141
   12 NDX(I+12)=ND(I)
      DO 10 I=5,51
      J1=(I-1)*3+1
      J2=I*3
      IF(I.EQ.24.OR.I.EQ.39) WRITE(3,6)
    6 FORMAT(1H )
      IF (I.EQ.39.OR.I.EQ.40) GO TO 13
      IF(I.GT.46) GO TO 9
      IF(I.GT.40.AND.I.LT.45) GO TO 9
      WRITE(3,7)  (NDX(JX),JX=J1,J2),E(I)
    7 FORMAT(1X,3A4,1X,F6.2)
      GO TO 10
   13 WRITE(3,33) (NDX(JX),JX=J1,J2), E(I)
   33 FORMAT (1X,3A4,1X,F6.5)
      GO TO 10
    9 WRITE(3,8) (NDX(JX),JX=J1,J2),E(I)
    8 FORMAT(1X,3A4,1X,F6.3)
   10 CONTINUE
      WRITE(3,6)
      RETURN
      END
```

```
      SUBROUTINE PT
      COMMON D(21,9),TAB(21,8),E(51)
      DIMENSION KTAB(21,2)
      DIMENSION TOT(21)
      DATA MINUS/4H-  -/
      DATA PLUS/4H+  +/
      DO 71 K=1,21
      KTAB(K,1)=K*5-5
   71 KTAB(K,2)=K*5-1
      TT=0.
      TT=TAB(4,8)+TAB(5,8)
      DO 16 I=1,21
   16 TOT(I)=TAB(I,1)+TAB(I,2)
      WRITE(3,50)
   50 FORMAT(1H )
      WRITE(3,8)
    8 FORMAT(2X,'AGE',4X,'BOTH SEXES',4X,'MALE',5X'FEMALE')
      WRITE(3,50)
      WRITE(3,61)  TT,TAB(4,8),TAB(5,8)
   61 FORMAT(2X,'ALL AGES',1X,F8.0,2X,F8.0,1X,F8.0)
      WRITE(3,50)
      DO 11 I=1,21
      IF(TOT(I+1)) 18,18,12
   18 WRITE(3,66) KTAB(1,1),PLUS,TOT(I),TAB(I,1),TAB(I,2)
      WRITE(3,50)
      GO TO 3
   66 FORMAT(2X,I3,1X,A1,4X,F8.0,2X,F8.0,1X,F8.0)
   12 CONTINUE
   11 WRITE(3,65) KTAB(I,1),MINUS,KTAB(I,2),TOT(I),TAB(I,1),TAB(I,2)
   65 FORMAT(2X,I3,A1,I3,2X,F8.0,2X,F8.0,1X,F8.0)
    3 RETURN
      END


      SUBROUTINE PTAB(NROW)
      COMMON D(21,9),TAB(21,8),E(51)
      WRITE(3,55)
   55 FORMAT(1H )
      DO 2 I=1,NROW
      IF(TAB(I,1)) 23,23,7
    7 IF(I.GT.8.AND.I.LT.12) WRITE(3,5)I,(TAB(I,J),J=1,8)
      IF(I.LT.9.OR .I.GT.11)WRITE(3,3) I,(TAB(I,J),J=1,8)
    2 CONTINUE
    3 FORMAT (1X,I2,    2(F8.0),1X,2(1X,F6.5),1X,F8.4,2(1X,F8.0),
     11X,F10.2)
    5 FORMAT (1X,I2,2(F8.0),1X,2(1X,F6.5),1X,F8.4,2(1X,F8.0),1X,F10.5)
   23 RETURN
      END
```

```
      SUBROUTINE PTP
      COMMON D(21,9),TAB(21,8),E(51)
      DIMENSION TTX(21),          TMX(21),TFX(21),TOT(21),KTAB(21,2)
      DATA MINUS/4H-  -/
      DATA PLUS/4H+  +/
      DO 71 K=1,21
      KTAB(K,1)=K*5-5
   71 KTAB(K,2)=K*5-1
      TT=0.
      DO 39 I=1,21
   39 TOT(I)=TAB(I,1)+TAB(I,2)
      TT=TAB(4,8)+TAB(5,8)
   75 FORMAT(2X,'ALL AGES',F8.0,1X,F8.0,F8.0,6X,F6.2,6X,F6.2,4X,F6.2)
      WRITE(3,49)
      DO 89 I=1,21
      TTX(I)=TOT(I)/TT*100.
      TMX(I)=TAB(I,1)/TAB(4,8)*100.
   89 TFX(I)=TAB(I,2)/TAB(5,8)*100.
      TP=0.
      TMP=0.
      TFP=0.
      DO 57 I=1,21
      TP=TP+TTX(I)
      TMP=TMP+TMX(I)
   57 TFP=TFP+TFX(I)
      WRITE(3,49)
   49 FORMAT(1H )
      WRITE(3,40)
   40 FORMAT(2X,'AGE',3X,'BOTH SEXES',3X,'MALE',4X,'FEMALE',3X,'% BOTH S
     1EXES',3X,'% MALE',3X,'% FEMALE')
      WRITE(3,49)
      WRITE(3,75) TT,TAB(4,8), TAB(5,8),TP,TMP,TFP
      WRITE(3,49)
      DO 18 I=1,21
      IF(TOT(I+1)) 24,24,31
   24 WRITE(3,44) KTAB(I,1),PLUS,TOT(I),TAB(I,1),TAB(I,2),TTX(I),TMX(I),
     1TFX(I)
      WRITE(3,49)
      GO TO 2
   31 CONTINUE
   18 WRITE(3,32) KTAB(I,1),MINUS,KTAB(I,2),TOT(I),TAB(I,1),TAB(I,2),
     1TTX(I),TMX(I),TFX(I)
   32 FORMAT (2X,I3,A1,I3,1X,F8.0,1X,F8.0,F8.0,6X,F6.2,6X,F6.2,4X,F6.2)
   44 FORMAT(2X,I3,1X,A1,3X,F8.0,1X,F8.0,F8.0,6X,F6.2,6X,F6.2,4X,F6.2)
    2 RETURN
      END
```

```
      SUBROUTINE SPP(R)
C SPP PRODUCES THE STABLE POPULATION FROM RNI+LIFE TABLE
      COMMON D(21,9),TAB(21,8),E(51)
      DIMENSION C(18),V(18),P(7,4)
      INTEGER SEX,REG
      DATA C/.5,3.0,7.5,12.5,17.5,22.5,27.5,32.5,37.5,42.5,
     147.5,52.5,57.5,62.5,67.5,72.5,77.5,80.0/
C ARRAY C=INTERVAL MIDPOINTS
      DATA P/.029,.055,.054,.037,.020,.004,.001, .018,.042,.056,.044,.02
     18,.010,.002, .008,.032,.054,.050,.034,.018,.004,.002, .019,.047,.0
     256,.046,.025,.005/
CLEAR E
      DO 10 I=1,51
   10 E(I)=0.0
C ESTIMATE AVERAGE AGE OF PERSONS IN THE OPEN INTERVAL
      C(18)=(80.0+.6*D(18,8)+.92)
COMPUTE ARGUMENT FOR EXP
      DO 11 J=1,18
   11 V(J)=-R*C(J)
CHECK ARGUMENT FOR SIZE (RETURN TO MAIN IF UNACCEPTABLE)
   20 DO 21 J=1,18
   21 E(39)=E(39)+D(J,5)*EXP(V(J))
C E439<=RECIPROCAL OF INTEGRAL S P(A)*EXP(-R*A)
      E(39)=1./E(39)
COMPUTE PERCENT IN AGE GROUP  VIA C(A)=P(A)*EXP(-R*A)/S P(A)*EXP(-R*A)
      DO 22 I=5,22
      E(I)=EXP(V(I-4))*D(I-4,5)*E(39)*100.
   22 E(23)=E(23)+E(I)
      E(24)=E(5)
      DO 23 I=25,37
   23 E(I)=E(I-1)+E(I-19)
      E(38)=E(23)
      E(39)=E(39)*100000.
      E(40)=E(39)-R
   30 DO 31 I=5,22
   31 E(45)=E(45)+E(I)*C(I-4)
      E(45)=E(45)/100.
      DO 32 I=9,14
   32 E(46)=E(46)+E(I)
      E(47)=E(39)/(E(46)*10.0)*1000.
      E(48)=(E(5)+E(6))/E(46)
      E(49)=(E(7)+E(8))/(E(23)-E(5)-E(6))
      E(50)=(E(27)+E(38)-E(36))/(E(36)-E(27))
      E(51)=1./E(39)
      DO 33 K=41,44
      DO 34 J=5,11
   34 E(K)=E(K)+EXP(V(J))*D(J,5)*P(J-4,K-40)
   33 E(K)=100000.0/E(K)
      RETURN
      END
```

```
      SUBROUTINE SR(SRB,OSR)
      COMMON A(21,9),B(21,8),C(51)
      OSR=(SRB/((B(1,1)/B(1,3))/(B(1,2)/B(1,4))))
      RETURN
      END
```

```
      SUBROUTINE T67
      COMMON D(21,9),TAB(21,8),E(51)
      DO 35 I=1,21
      TAB(I,1)=TAB(I,6)
   35 TAB(I,2)=TAB(I,7)
      RETURN
      END
```

VI. Miscellaneous Information

A. Subroutine Name Mnemonics

CPT: convert percents to totals
ELT: empirical life table
LPT: load projection table
LMFP: load model fertility pattern
LMFPX: load model fertility pattern
LPOP: load population
LSP: load stable population

LSR: load survival ratios
MLT: model life table
MLTX: model life table
MXQX: converts M_x values to Q_x values
PART: partition total population into male and female totals
PLT: print life table
PROJ: project

PP: print percents
PSPP: print stable population parameters
PT: print totals
PTAB: print (projection) table
PTP: print totals and percents
SPP: stable population parameters
SR: sex ratio
T67: transfer columns 6 and 7

B. Summary of the Required Form of DCL CALL Statements

```
CALL CPT (TM,TF)
CALL ELT (NSEX)
CALL LPT (EM,EF,R,NREGM,NREGF,STEP)
CALL LMFP (N,TFR)
CALL LMFPX (N,CBR)
CALL LPOP (ARRAY,NSEX)
CALL LSP (NSEX)

CALL LSR (NSEX)
CALL MLT (EX,NSEX,NREG)
CALL MLTX (ET,NSEX,NREG)
CALL MXQX (EMX,NSEX)
CALL PART (OSR,T,TM,TF)
CALL PLT (NROW)
CALL PP
CALL PROJ
CALL PSPP
CALL PT
CALL PTAB (NROW)
CALL PTP
CALL SPP (R)
CALL SR (SRB,OSR)
CALL T67
```

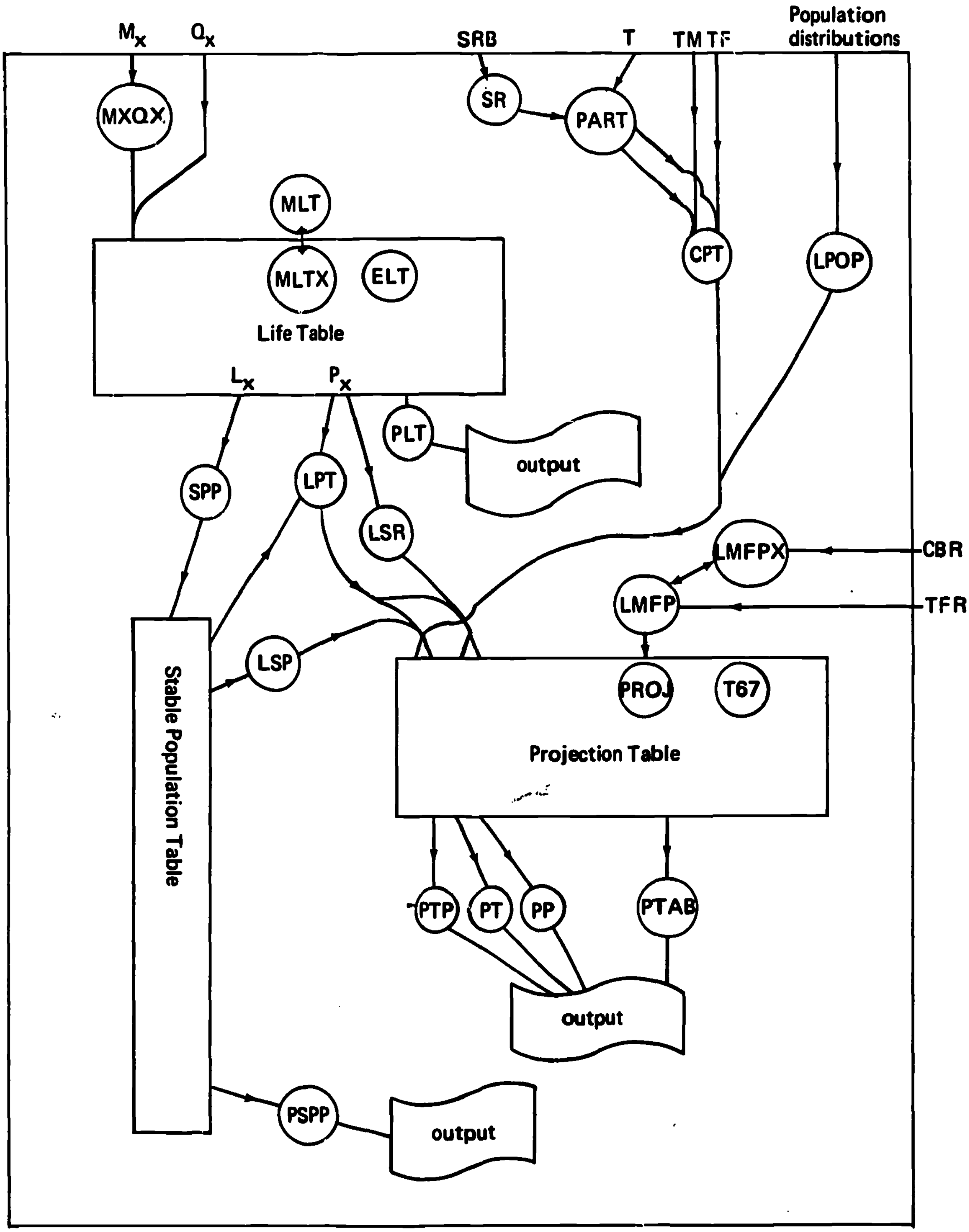
Definition of symbolic names used as arguments:

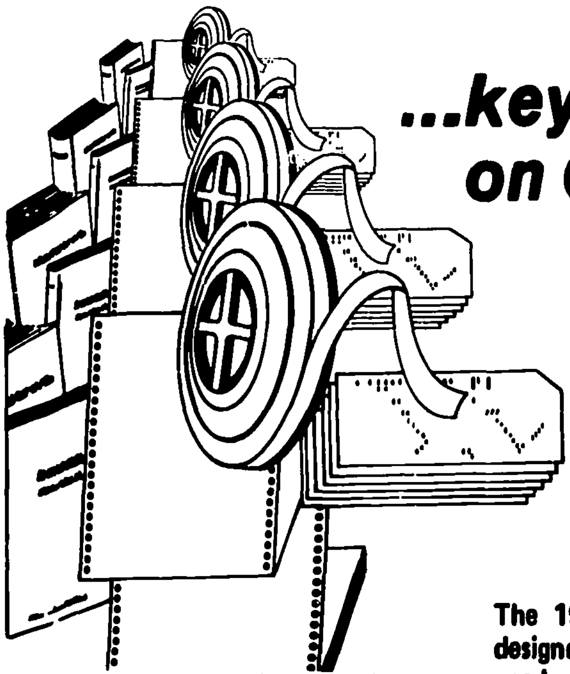
ARRAY: the name of the 21 word array containing the population distribution of the sex indicated by NSEX
CBR: crude birth rate, unit basis
EF: female life expectancy at birth
EM: male life expectancy at birth
EMX: the name of the 21 word array containing the set of M_x values
ET: control variable (see description of MLTX.)
EX: life expectancy at birth
N: model fertility pattern code (see description of subroutine LMFP)
NREG: model life table region code (1 = West, 2 = North, 3 = East, 4 = South)
NREGF: NREG for females
NREGM: NREG for males
NROW: number of rows to be printed
NSEX: sex code (1 = females, 2 = males)
OSR: overall sex ratio, unit basis
R: rate of natural increase, unit basis
SRB: sex ratio at birth, unit basis
STEP: average annual increment to life expectancy at birth for the 5-year projection interval
T: total population, both sexes
TF: total female population
TFR: total fertility rate
TM: total male population

C. Schema of DCL Relationships

Diagram 3 presents a schema that reveals at a glance the network of DCL relationships. The symbols on the margin of the diagram represent data inputs, the boxes represent the three principal arrays, and the circles represent DCL subroutines. Wherever it could be done easily, the locations of subroutine inputs and outputs are indicated by directed lines. Output external to the computer is indicated by the three curved boxes.

Diagram 3. Schema of DCL Relationships





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